

AMENDMENT UNDER 37 C.F.R. § 1.111
U.S. Application No. 10/511,084

AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph no. [0001] with the following amended paragraph:

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] ~~This application is related to two other U.S. patent applications, filed on even date, entitled "Dark Field Inspection System" and "Illumination System for Optical Inspection." Both of these related applications are incorporated herein by reference.~~ The present application claims priority to and is National Stage Entry of application no. PCT/US03/28061, published as WO/2004/031753, entitled "Inspection System with Oblique Viewing Angle," filed on September 8, 2003, which is a non-provisional application claiming priority to provisional application no. 60/415,082 titled "Inspection System with Oblique Viewing Angle," filed on September 30, 2002, which are hereby incorporated by reference herein. This application is also related to U.S. patent application Serial Number 10/511,092, filed on April 26, 2005, titled "Dark Field Inspection System" and U.S. patent application Serial Number 10/511,085, filed on October 14, 2004, titled "Illumination System for Optical Inspection." Both of these related applications are incorporated herein by reference.

Please replace the paragraph no. [0038] with the following amended paragraph:

[0038] The radiation scattered from wafer 22 is collected over a large range of angles by an optical collection module 26. Module 26 comprises collection optics 28, which image the surface of wafer 22 onto multiple cameras 30. Optics 28 may comprise either a single objective with high numerical aperture (NA) or a collection of individual objectives, one for each camera. Details of both of these alternative optical configurations, as well as of cameras 30, are described

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hereinbelow. Optics 28 and cameras 30 are arranged so that all the cameras image the same area on the wafer surface, i.e., the area illuminated by illumination module 24, while each camera captures the radiation that is scattered into a different angular range. Each camera 30 comprises a two-dimensional array of detector elements, such as a ~~CCD~~ charge-coupled device (CCD) or ~~CMOS~~ complimentary metal oxide semiconductor (CMOS) array, as is known in the art. Each detector element of each of the arrays is imaged onto a corresponding spot within the area irradiated by illumination module 24. Thus, the scattering characteristics of any given spot on wafer 22 as a function of angle can be determined based on the signals generated by the corresponding detector elements in the different cameras 30.

Please replace the paragraph no. [0043] with the following amended paragraph:

[0043] In order to verify and adjust the focus, controller 32 uses an auto-focus illuminator 40 and an auto-focus sensor module 42. Illuminator 40 typically comprises a laser (not shown), such as a ~~CW~~ continuous-wave (CW) diode laser, which emits a collimated beam at an oblique angle onto or adjacent to the area of the surface of wafer 22 that is illuminated by illumination module 24, forming a spot on the wafer surface. Variations in the Z-position of wafer 22 relative to collection module 26 will then result in transverse displacement of the spot. Sensor module 42 typically comprises a detector array (also not shown), which captures an image of the spot on the wafer surface. The image of the spot is analyzed in order to detect the transverse position of the spot, which provides controller 32 with a measurement of the Z-position of the wafer surface relative to the collection module. The controller may drive stage 36 until the spot is in a pre-calibrated reference position, indicative of proper focus.

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Please replace the paragraph no. [0048] with the following amended paragraph:

[0048] The expanded beams output by telescopes 56 are conveyed by collimating lenses 58 to variable optical density filters 60. These filters, which may conveniently be mounted in rotatable filter wheels, allow the intensities of the two laser beams on wafer 22 to be adjusted, depending on application requirements. Polarizers 62 may similarly be rotated to determine the angles of polarization of the beams. Pick-off beamsplitters 64 deflect a small, known portion of the light in each of the laser beams toward respective energy meters 66 as shown in Figure 11. The energy meters provide a measurement of the intensity of each of the laser beams, for use by image processor 34 in correcting for pulse-to-pulse energy deviation, and possibly providing feedback control to laser head 50. Energy meters 66 may also be used to provide a synchronization input to cameras 30, as described below.

Please replace the paragraph no. [0049] with the following amended paragraph:

[0049] An optical switching module 70, comprising relay mirrors 68, allows the beam path of each of the laser wavelengths to be selected so that each wavelength may be incident on wafer 22 at either a normal or oblique angle of incidence as shown in Figure 4. Switching module 70, which is described in greater detail hereinbelow, thus feeds both normal output optics 72 and oblique output optics 74. Oblique optics 74 are typically configured to illuminate the wafer surface at an angle between about 5.degree. and 50.degree. from the surface, although larger and smaller illumination angles are also possible. Optics 72 and 74 typically have numerical apertures (NA) in the range between about 0.01 and 0.2. The switching module may also be set to block one of the laser wavelengths, so that only a single wavelength is incident on the wafer

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(either normally or obliquely). When both wavelengths are used simultaneously, a chromatic compensation element 76, typically comprising suitable lenses, may be introduced into the path of one of the beams (in this embodiment the oblique beam) so that both the oblique and normal beams illuminate the same area on the wafer surface with substantially the same geometrical profile.

Please replace the paragraph no. [0073] with the following amended paragraph:

[0073] The output of image intensifier 162 is focused by relay optics 164 onto an image sensor 166 as shown in Figure 9. The relay optics may comprise, for example, either a relay lens or a fiberoptic faceplate coupled directly to the image sensor chip. Image sensor 166 comprises a two-dimensional matrix of detector elements, such as a CCD or CMOS array, as is known in the art. For example, the image sensor may comprise a CMOS digital image sensor, such as model MI-MV13, made by Micron Technology Inc. (Boise, Id.). This sensor has 1280.times.1024 pixels, with 12 .mu.m vertical and horizontal pitch, and a frame rate up to 500 frames per second for full frames.

Please replace the paragraph no. [0078] with the following amended paragraph:

[0078] FIG. 7 is a schematic side view of collection module 26, in accordance with another embodiment of the present invention. In this case, module 26 comprises multiple, separate imaging channels 190, each with its own collection optics, rather than a single shared objective as in FIGS. 5 and 6. Channels 190 are distributed to collect the light scattered from wafer 22 at different, respective angles. As its objective, each channel comprises an afocal relay 192 and a tilt correction unit (TCU) 194 as shown in Figure 9, which form an intermediate image

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196 of the wafer surface. A magnification module (MGM) 198 focuses the intermediate image, with adjustable magnification, onto the entrance plane of camera 30. As noted above, the entrance plane of the cameras in system 20 is typically the photocathode plane of an image intensifier that forms part of the camera, as described above.